be seated directly against the surface of such a display, over the border surrounding its active area. In another embodiment, as mentioned above, the overlay may be replaced by a structure including a display unit, such as an LCD.

[0048] A capacitive sensor **220** may be positioned between the touch surface **210** and the housing **215**. An interconnect **225**, with attachment lands **233**, may be coupled to the housing **215** by soldering, cementing, or by other methods. A conductive area forms a first conductive element **234** on the interconnect **225**. A second conductive element **235** with a central protrusion **240**, for example a dimple, may be attached to the lands **233** of the interconnect **225** by soldering, for example. A small gap **280** is formed between the first conductive element **234** and the second conductive element **235**, either by the shape of the second conductive element **235**, or by the process of attaching the second conductive element **235** to the interconnect **225**. The width of the gap **280** may be approximately 1 mil, for example. A capacitor is formed by the conductive elements **234**, **235** separated by the gap **280**.

[0049] An optional bearing surface **270** may be interposed between the touch surface **210** and the second conductive element **235**. This may protect the touch surface **210** from indentation or from damage by the protrusion **240**, especially in cases where the overlay is made of softer material. The bearing surface **270** may also mount to the touch surface **210** through a thin layer (not shown) of elastomer or of highly pliable adhesive, thereby providing a lateral softening function. It will be appreciated that, in normal operation, the touch surface **210** or bearing surface **270** is in contact with the protrusion **240**: these elements are shown separated only for clarity in the illustration.

[0050] The second conductive element **235** combines the functions of a spring and a capacitor plate. As a perpendicular force is applied to the touch surface **210**, the second conductive element **235** flexes, decreasing the width of the gap **280** and increasing the capacitance of the sensor **220**. This change in capacitance may be measured and related to the force applied to the touch surface **210**. Although a touch screen using capacitive force sensors is described, other types of force sensors may be used in a similar manner, including, for example, piezoelectric sensors and strain gauge sensors.

[0051] One of the advantages of a force-based touch screen is that the number of optically distinct layers positioned between the display unit and the user is low. Typically, the overlay positioned over the display unit is a single layer of glass or relatively stiff polymer, for example polycarbonate or the like, which may be chosen for suitable optical qualities. This contrasts with other types of touch screen, such as resistive or capacitive touch screens, that require several, potentially optically lossy, layers over the display unit. The electrically conductive thin films required in resistive or capacitive touch screens typically have a high index of refraction, leading to increased reflective losses at the interface. This is a particular problem in resistive screens where there are additional solid/air interfaces and where antireflection coatings are not useful, since the conductive layers must be able to make physical contact. A screen overlay for a force-based touch screen, however, has only its upper and lower surfaces; these may be treated to reduce reflective losses and to reduce glare. For example, the overlay may be provided with matte surfaces to reduce specular reflection, and/or may be provided with anti-reflection coatings to reduce reflective losses.

[0052] A perspective view of a touch screen is schematically illustrated in **FIG. 3**. A touch surface **300** is shown disposed proximate to force sensors **310**, **320**, **330**, **340** located at respective corners of the touch surface **300**. As a stylus, finger or other touching device **352** presses the touch surface **300**, a touch force **355** is exerted upon the touch surface **300** at the touch location **350**. The touch force **355** creates forces F1, F2, F3, F4 on the force sensors **310**, **320**, **330**, **340** perpendicular to the touch surface **300**. The force sensors **310**, **320**, **330**, **340** may be driven with an alternating electrical signal. The perpendicular forces F1, F2, F3, F4 cause a change in the capacitance of the force sensors **310**, **320**, **330**, **340**, thereby causing the signal coupled through the force sensors **310**, **320**, **330**, **340** to change. The force responsive signals derived from the force sensors **310**, **320**, **330**, **340** may be used to calculate touch location.

[0053] Calculation of the touch location may be performed, for example, using combinations of the force responsive touch sensor signals. The force responsive signals generated by the touch sensors may be used to calculate various touch signals, including the moment about the y-axis, M_Y, moment about the x-axis, M_x, and the total z-direction force, F_{Tz}. The coordinates of the touch location may be determined from the touch sensor signals, as provided in Equation 1, assuming a reference point in the center of the touch screen, ideal conditions, with no errors, background fluctuations or disturbances present other than the touch force.

$$X = \frac{M_y}{F_{T_z}} \qquad [1]$$

$$Y = \frac{M_x}{F_{T_z}}$$

[0054] where

$M_x=(F1+F2)-(F3+F4)$;

$M_y=(F2+F4)-(F1+F3)$; and

$F_{Tz}=F1+F2+F3+F4$.

[0055] Exemplary waveforms representing various profiles of a touch signal, such as the total z-direction force, F_{Tz}, are illustrated in **FIG. 4** for various touch types. Although the touch signal profiles of the total force, F_{Tz}, are illustrated, other combinations of the sensor signals produce similar profiles.

[0056] The shape of the touch signal profiles for various touch types may vary significantly depending on the type of touch. The profile of a tap touch **410** has relatively short rise and fall times and may occupy a relatively short time interval, for example approximately 15 msec. The profile of a soft touch **420** may exhibit a slower rise time and longer duration. However, the relative magnitudes of the touch signals may be unpredictable. A continuing touch signal may represent a touch lingering in one location on the touch screen, or may represent a touch moving across the touch screen. The moving touch may be used to perform drawing or drag-and-drop functions, for example. The profile for a moving touch may last for a relatively long time, for example, 2 sec or longer.